

What is claimed as new and desired to be protected by Letters

Patent of the United States is:

1. A method of forming a mask, comprising:

forming a first layer of material over a substrate;

forming an opaque layer overlying said first layer of material,

said opaque material layer having at least one opening therein filled with a

second material, said second material residing over said first layer of

material and defining areas of said first layer of material which are to be

removed;

using said second material as a mask to remove said areas of

said first layer of material; and

removing said second material.

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2. The method of claim 1, wherein the using of said second material as a mask comprises providing a first region from which said first layer of material is removed, and the removing of said second material comprises providing a second region from which said second material is removed, said first and second regions having different phase shift characteristics with respect to light transmitted therethrough.

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3. The method of claim 2, wherein said first region provides a phase shift with respect to light transmitted therethrough of 180 degrees and said second region provides a phase shift with respect to light transmitted therethrough of zero degrees.

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4. The method of claim 2, wherein said first region provides a phase shift with respect to light transmitted therethrough of zero degrees

and said second region provides a phase shift with respect to light transmitted therethrough of 180 degrees.

5. The method of claim 2, wherein said first and second regions form a rim type phase-shifter.

6. The method of claim 2, wherein said at least one opening comprises a plurality of openings.

7. The method of claim 6, wherein said first and second regions form a Levenson-type phase-shifter.

8. The method of claim 1, wherein the forming of said opaque layer comprises:

depositing a first resist material on said opaque layer;

removing a portion of said first resist material, leaving said opening;

15 etching an uncovered portion of said opaque layer underlying the removed portion of said first resist material, thereby deepening said opening; and

removing the remainder of said first resist material.

9. The method of claim 8, wherein the using of said second material as a mask comprises:

20 providing said second material within said opening and over said opaque layer;

directing a first exposure through said substrate to expose a

portion of said second material;  
hardening the exposed portion of said second material;  
directing a second exposure at said second material to  
remove any unhardened portions of said second material;  
5 providing a third material over said opaque layer and said  
hardened portion of said second material;  
performing a lithographic step on a portion of said third  
material overlying and bounded by said second material to expose and  
remove said portion of said third material; and  
10 etching said first layer of material underlying said exposed  
and removed portion of said third material.

10. The method of claim 9, wherein said second material is a  
positive-tone resist material capable of making an image reverse tone.

11. The method of claim 9, wherein the exposed portion of said  
second material is hardened by baking.  
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12. The method of claim 1, wherein said first layer of material  
comprises a material adapted to allow a 180 degree phase shift with respect  
to open areas of said substrate.

13. The method of claim 12, wherein said first layer of material  
20 comprises one or more from the group consisting of molybdenum-silicide,  
chromium-fluoride, silicon nitride-titanium nitride, tantalum silicide, and  
zirconium silicon oxide.

14. The method of claim 13, wherein said first layer of material comprises molybdenum-silicide.

15. The method of claim 13, wherein said first layer of material comprises chromium fluoride.

5 16. The method of claim 1, wherein said substrate comprises a material transparent to ultraviolet light.

17. The method of claim 16, wherein said substrate comprises quartz.

10 18. The method of claim 1, wherein said opaque layer comprises chromium.

19. A mask formed by the method of claim 1.

20. A method of forming a mask, comprising:  
forming an opaque layer over a substrate, said opaque layer  
having at least one opening therein filled with a first material, said first  
material defining areas of said substrate which are to be removed;  
using said first material as a mask to remove said areas of said  
substrate; and  
removing said first material.

15 21. The method of claim 20, wherein the using of said first  
material as a mask comprises providing at least one first region from which  
said opaque material is removed, and the removing of said first material

comprises providing at least one second region from which said first material is removed, said first and second regions having different phase shift characteristics with respect to light transmitted therethrough.

5           22. The method of claim 21, wherein said first region provides a phase shift with respect to light transmitted therethrough of 180 degrees and said second region provides a phase shift with respect to light transmitted therethrough of zero degrees.

10          23. The method of claim 21, wherein said first region provides a phase shift with respect to light transmitted therethrough of zero degrees and said second region provides a phase shift with respect to light transmitted therethrough of 180 degrees.

24. The method of claim 21, wherein said first and second regions form a rim type phase-shifter.

15          25. The method of claim 21, wherein said at least one first region comprises a plurality of first regions and wherein said at least one second region comprises a plurality of second regions.

26. The method of claim 25, wherein said at least one of said first and second regions form a rim type phase-shifter.

20          27. The method of claim 26, wherein said at least one of said first and second regions form a Levenson-type phase-shifter.

28. The method of claim 20, wherein the forming of said opaque layer comprises:

depositing a first resist material on said opaque layer;

removing a portion of said first resist material, leaving said

5 opening;

etching an uncovered portion of said opaque layer underlying the removed portion of said first resist material, thereby deepening said opening a first time; and

removing the remainder of said first resist material.

10 29. The method of claim 28, further comprising etching the substrate defined by said deepened opening, thereby deepening said opening a second time.

30. The method of claim 29, wherein the using of said first material as a mask comprises:

15 providing said first material within said twice deepened opening and over said opaque layer;

directing a first exposure through said substrate to expose a portion of said first material;

hardening the exposed portion of said first material;

20 directing a second exposure at said first material to remove any unhardened portions of said first material;

providing a second material over said opaque layer and said hardened portion of said first material;

performing a lithographic step on a portion of said second material overlying and bounded by said first material to expose and remove said portion of said second material; and

etching said opaque layer underlying said exposed and removed portion of said second material.

31. The method of claim 30, wherein the exposed portion of said first material is hardened by baking.

32. The method of claim 30, wherein said first material is a positive-tone resist material capable of making an image reverse tone.

10 33. The method of claim 28, wherein the using of said first material as a mask comprises:

providing said first material within said deepened opening and over said opaque layer;

directing a first exposure through said substrate to expose a portion of said first material;

baking said first material to harden the exposed portion of said first material;

directing a second exposure at said first material to remove any unhardened portions of said first material;

20 providing a second material over said opaque layer and said hardened portion of said first material;

performing a lithographic step on a portion of said second material overlying and bounded by said first material to expose and remove

said portion of said second material; and

etching said opaque layer underlying said exposed and removed portion of said second material.

34. The method of claim 33, further comprising etching said substrate underlying said etched opaque layer and removing the remainder of said first and second materials.

35. The method of claim 33, wherein said first material is a positive-tone resist capable of making an image reverse tone.

36. A mask formed by the method of claim 20.

37. A mask comprising at least one printable area which is self-aligned with respect to an adjacent phase shift area.

38. The mask of claim 37, wherein said printable area comprises a printable contact area.

39. The mask of claim 37, wherein said printable area comprises a printable line area.

40. The mask of claim 37, wherein said mask is a reticle.

41. The mask of claim 37, wherein said mask comprises a substrate and an opaque layer.

42. The mask of claim 41, wherein said printable area is located within said substrate and said adjacent phase shift area is located in said opaque layer.

5 43. The mask of claim 42, wherein said substrate is formed of quartz and said opaque layer is formed of chromium.

44. The mask of claim 41, further comprising a layer overlying said opaque layer, said printable contact area being formed in said opaque layer and said adjacent phase shift area being formed in said layer.